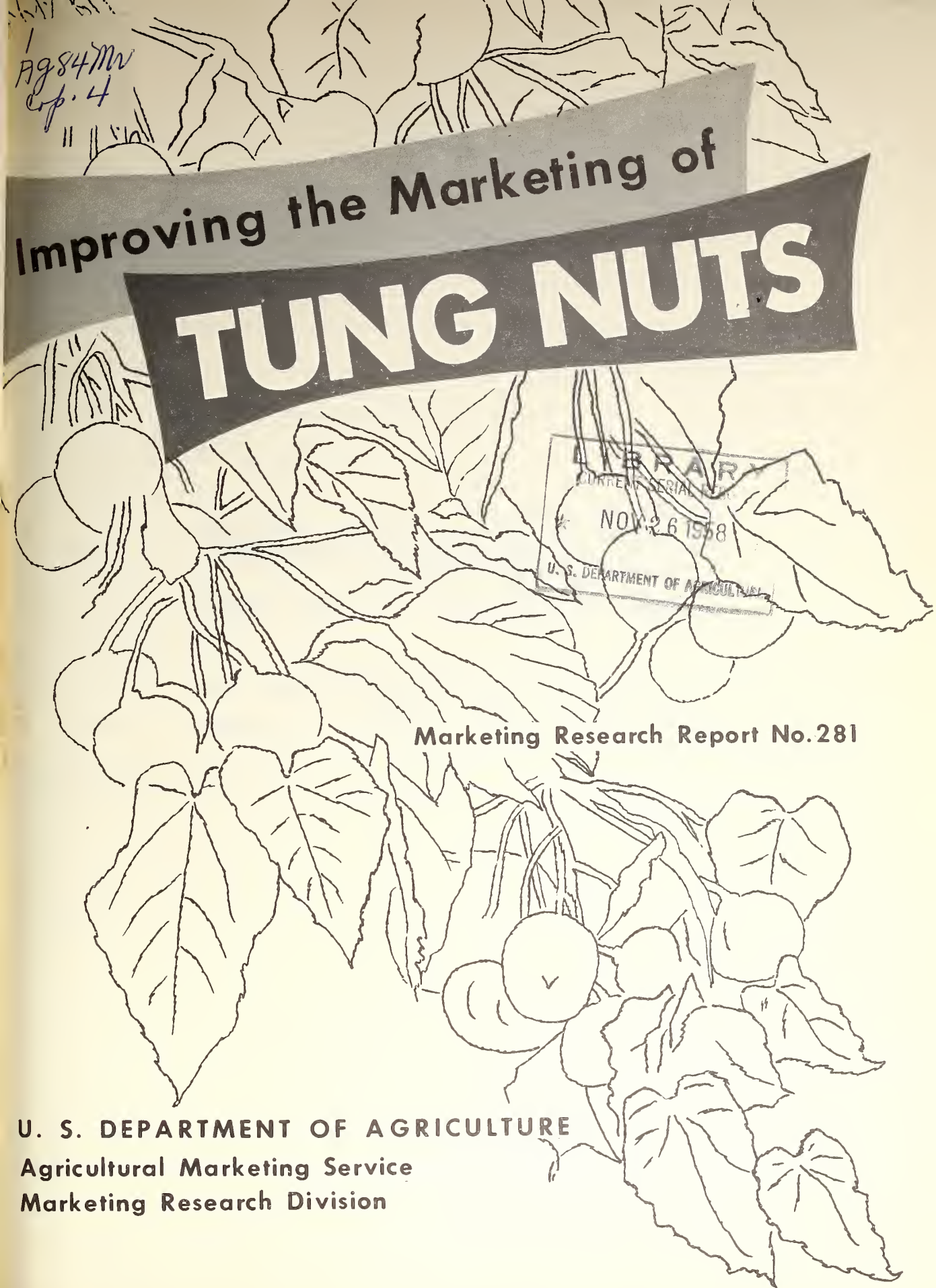
Improving the Marketing of TUNG NUTS



Marketing Research Report No. 281

U. S. DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Marketing Research Division

Baumann, Lewis Albert, 1897–

Improving the marketing of tung nuts. [Washington] U. S. Dept. of Agriculture, Agricultural Marketing Service, Marketing Research Division [1958]

vi, 31 p. charts, tables. 27 cm. (U. S. Dept. of Agriculture. Marketing research report no. 281)

1. Tung nut[—Marketing] 2. [Tung nut—Stat.] 3. [Tung oil and tung oil tree—Stat.] I. Title. (Series)

[HD1751.A9183 no. 281] 338.17385 Agr 58-283

[U. S. Dept. of Agr. Libr. 1Ag84Mr no. 281
for Library of Congress

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November 1958

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. - Price cents

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PREFACE

The study is part of a broad program of research in the U. S. Department of Agriculture to improve efficiency in the marketing of farm products, and to expand markets.

This study was planned and initiated under the supervision of Donald Jackson, agricultural economist, Agricultural Marketing Service, U. S. Department of Agriculture. Mr. Jackson is now in charge of the Marketing Research Field Station in Berkeley, Calif.

Dr. George F. Potter, principal physiologist, and Dr. R. S. McKinney, chief chemist, U. S. Field Laboratory for Tung Investigations, made recommendations for the sampling and testing technique.

The samples were drawn by the Fruit and Vegetable Division, Agricultural Marketing Service, under the supervision of Earl F. Burk and S. S. Farmer. Samples were supplied free of charge by those processing mills who took part in the study.

The American Tung Oil Association, The Marketing Co-op and Research League, and The Tung Growers Council of America gave helpful suggestions during the project.

Earlier publications on tung issued by the U. S. Department of Agriculture include:

"Tung Production." Farmers' Bulletin No. 2031. December 1951.
"Tung Processing and Marketing Practices and Costs." Marketing Research Report No. 10. June 1952. (Out of print; may be consulted in libraries.)
"Tung." Twenty years of research. 1935-55. (An abstract bibliography of publications on tung.) Agricultural Research Service, November 1956.

SUMMARY AND CONCLUSIONS

How much tung nut growers get for their crop depends mainly on the size of the crop and the quantity of oil it contains, as estimated by the processor. Processors who follow closely the standard sampling procedure developed by the American Oil Chemists' Society make it possible for producers to get prices that are more nearly equitable than they could get otherwise.

There is so much variation in the oil content even within a single load and among different loads from the same orchard, as well as among loads from different orchards that it is particularly important to draw a sample large enough to fill a 50-pound lard can from each load in such a way that it is representative of all parts of the load. Failure to follow this part of the standard sampling procedure is likely to result in substantial underpayment or overpayment to the individual producer, for his oil.

Farmers could reduce their hauling and processing costs by hulling the tung nuts, and by lowering the moisture content through improved farm storage facilities. However, this study did not determine the added costs of improved storage. Moreover, further improvement is needed in mechanical harvesting, and particularly in field hulling equipment. A small producer could not afford to own and operate such equipment for a single orchard. He could join with others in a cooperative, or use his equipment to hull nuts for other farms for a fee at a central location. Portable hulling equipment has not proven economically successful.

Tung oil, one of the more important of the quick-drying oils, has been used in manufacturing for many years. Its important uses now are in the manufacture of linoleum and oilcloth, printing ink products, and military goods. It was classified by the Government as one of the six strategic oils during World War II.

Almost all tung nuts grown by independent producers in the United States are "custom-milled" or "toll-processed." The mill tests the tung nuts received from each grower for oil content, and guarantees him a certain percentage of that oil. The grower may then sell his oil individually, or through a cooperative; or he may let the mill sell it for him. His contract may call for a discount at the end of the season if the mill fails to recover as large a percent of the oil as it expected, or call for a premium if the mill recovers a larger percentage of oil during the season than it expected.

Processing and transportation charges paid by producers total around $15.50 per ton of nuts. The mill usually retains the byproducts from the crushings as well as that part of the oil recovered which exceeds the quantity guaranteed. Contracts generally guarantee recovery of 86 percent or more of the oil in the tung nuts. Actual recovery by mills averaged 90.9 percent for the 1954-55 season, and 92.7 percent for the 1956-57 season.

The returns to the producer depend primarily on the amount of oil in the tung nuts when delivered to the processors's mill. A 1-percent difference in the test of oil in a ton of nuts equals 20 pounds of oil, which at 22 cents per pound amounts to $4.40. For a 50-ton crop, this amounts to around $200. And producers have reported far greater differences than 1 percent in the tests of 2 or more samples taken from the same orchard and even from the same load.

To determine the extent of variations in oil content, tests were conducted involving 250 loads of tung nuts in the 1954-55 harvesting season and 300 loads in the 1956-57 harvesting season. The oil content varied from a low of 8.1 percent of oil to a high of 25.3 percent. In 60 percent of the cases the oil content fell within a range of 15.0 to 19.6 percent. At 22 cents per pound of oil this meant a range of from $66.00 to $86.24 in the price per ton of unhulled nuts.

The samples tested came from over 200 orchards, and the range in oil content among loads from any given orchard was much lower than the range for all loads. Loads from the same orchard showed a range in oil content of only 7.1 percent, and 60 percent of the tests fell within a range of 1.8 percent. Even smaller variations were observed among samples drawn from the same load of nuts. Samples drawn from selected parts of particular loads yielded results similar to those obtained from samples taken at the unloading chute.

The average oil content of nuts sampled in 1956-57 was about 0.7 percent lower than in 1954-55. This decline appears to be associated with a higher moisture content in 1956-57 since there was no significant difference between these 2 years in the oil content determined on the basis of clean dry nuts. The method of storage of the nuts at the orchard accounts for this increased moisture content during 1956-57 over 1954-55. Nuts stored in bins during 1956-57 showed an average moisture content of 7.5 percent less than nuts stored on the ground. Sixty-five percent of all the nuts were stored on the ground in 1956-57 as compared with 54 percent in 1954-55. Moisture content of nuts stored on the ground was also 4 percent higher in 1956-57 than in 1954-55. If all nuts had been stored in bins immediately instead of being left on the ground until time for processing, they would have contained much less moisture. This reduction in the usual moisture content would have saved the producers over $50,000 in hauling and processing charges on approximately 50,000 tons of nuts custom-milled.

The present study has served to emphasize the wide variations in the composition of the tung nuts and the many factors that affect the oil content as delivered at the mills in the marketing operations of the producer. Present methods of harvesting, handling, storing, and sampling the tung crop are costly and not altogether satisfactory.

The heterogeneity of even small lots of tung nuts, of portions drawn for samples, and of loads of tung nuts from a single orchard makes it difficult for the laboratory analyst to compute with any great degree of accuracy the outturn which can be expected from processing an individual grower's tung crop. If samples are taken of a great number of loads from a single orchard, the analysis for oil should approach the average yield which the mill may expect to get.

IMPROVING THE MARKETING OF TUNG NUTS

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Market Organization and Costs Branch
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PRODUCTION OF TUNG OIL

The tung tree has been grown in China for many years--tung oil is processed from the kernels of the nuts. Trees were introduced in the United States in 1905 but it was not until the 1920's that processing mills were established for commercial production of the oil. Production of the oil in the United States was insignificant until the late 1930's, and China supplied about all the needs of United States industry, which at that time used as much as 175 million pounds annually. Imports from China were blocked by Japan during World War II, but were resumed after the war only to be banned by the United States in 1950. The embargo still remains.

Industry adjusted itself to the smaller supplies of tung oil during World War II, but by 1946 had again started using increasingly greater quantities. The amounts being produced by the United States in the late 1940's were inadequate for industry's requirements and, with decreasing and finally no imports from China, by 1950 the needed oil was imported from Argentina. Small amounts were also imported from Paraguay and Brazil around 1950. The bulk of Argentina's production has been imported by the United States in recent years (table 1).

United States production increased to peak quantities in 1952 and 1953, averaging 41.5 million pounds. Industry has, however, decreased its use to an amount which has been uniform since 1951, namely, around 50 million pounds annually. Severe frost damage to the tung trees in 1954-55, followed by an almost total loss of the crop in 1955-56, resulted in the disposition of Commodity Credit Corporation stocks acquired from the 1952 and 1953 crops. Furthermore, to meet domestic demand required high imports. Although frost damage has been high in recent years, normal weather expectancy for the future would indicate an average production of oil around 32 million pounds annually. This would leave around 20 million pounds of oil to be imported annually at the present rate of domestic use.

THE TUNG BELT

Tung culture is limited to a belt about 100 miles wide on the Gulf of Mexico, extending from southeast Texas through to the northeastern part of Florida. This area has the necessary climatic and soil requirements for growing tung trees, as well as low-priced land and available labor.

Table 1.--Tung oil: Supply and disposition in the United States, calendar year average, 1935-39 and 1940-41, and year beginning November 1942-57 1/

Period	Supply							Disposition	
	Carryover stocks	Production	Imports				Total	Exports 2/	Domestic disappearance
			China	Argentina	Others	Total			
	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.	Mil. lb.
Average 1935-39	37.9	0.6	122.7	--	0.5	123.2	161.7	5.7	118.1
Average 1940-41	3/	3.2	3/	--	3/	3/	3/	3/	3/
1942	31.4	5.2	--	--	3/	4/	36.7	1.8	5/11.5
1943	28.7	1.9	--	--	3/	1.8	32.3	.7	5/10.5
1944	22.8	8.8	--	--	3/	.3	31.9	2.5	21.7
1945	7.7	9.1	--	--	3/	24.5	41.3	.9	33.2
1946	7.2	14.4	103.3	--	.1	103.4	125.0	6.0	87.1
1947	31.9	16.0	140.2	--	.2	140.4	188.4	10.4	130.4
1948	47.6	17.0	61.9	9.2	1.3	72.4	137.0	10.9	107.7
1949	18.5	26.8	79.4	24.6	1.9	105.9	151.1	8.2	112.5
1950	30.5	12.3	33.9	12.4	1.9	48.2	91.0	6.4	5/72.4
1951	16.0	14.7	4/	24.4	6.0	30.4	61.2	1.3	51.2
1952	8.7	43.4	--	9.5	3.5	13.0	65.1	.3	49.6
1953	15.1	39.6	--	36.5	5.0	41.5	96.3	.3	49.3
1954	46.7	15.2	--	22.3	2.9	25.2	87.1	3.6	51.2
1955	32.4	2.0	--	26.2	5.2	31.4	65.8	1.4	51.4
1956 6/	13.0	32.0	--	31.5	--	31.5	76.5	1.3	50.4
1957 7/	24.8	25.5	--	26.0	3/	26.0	76.3	--	45.0
1958 8/	30.0								

1/ Data by crop year not available until 1942-43.
2/ Includes reexports.
3/ Data not available.
4/ Less than 50,000 pounds.
5/ Factory consumption figures are used for years in which factory consumption exceeded domestic disappearance.
6/ Preliminary.
7/ Partly estimated.
8/ Forecast.

Bureau of the Census and U. S. Department of Agriculture.

Although the first tung trees were planted in north central Florida, plantings have increased more in the western area of the belt. In 1930, 85 percent of the tung trees in the belt were in Florida. This percentage had decreased to about 25 percent by 1945. Table 2 shows that in 1954 over 50 percent of the trees were in Mississippi (with the highest concentration in Pearl River County). Twenty-five percent are still in Florida and about 20 percent in Louisiana.

Table 2.--Whole tung nuts: Number of tung farms and trees reported, by States and United States, 1950 and 1954

State	1950				1954			
	Farms	Trees			Farms	Trees		
		Not of bearing age	Of bearing age	Total		Not of bearing age	Of bearing age	Total
	No.	Thous.	Thous.	Thous.	No.	Thous.	Thous.	Thous.
Alabama	539	105	252	357	182	21	361	382
Florida	800	424	2,764	3,188	302	904	2,488	3,392
Georgia	454	31	100	131	59	1/	38	38
Louisiana	874	436	2,837	3,273	331	618	2,224	2,842
Mississippi	2,811	1,149	4,878	6,027	2,340	688	6,317	7,005
Others 2/	19	1	5	6	6	--	4	4
United States	5,497	2,146	10,836	12,982	3,220	2,231	11,432	13,663

1/ Less than 500.
2/ Mostly in Texas, rest in California and South Carolina.

Bureau of the Census.

It would appear that new plantings are being made mainly as replacements and that the rate of increase in trees in the belt is quite low. From the total number of trees bearing nuts (11,655,000), an average yield of 17.8 pounds of nuts per tree can be calculated for the belt for the 1956 season (table 3).

The tung industry has grown in the past 10 years (table 4), but in view of the plantings of nonbearing trees reported in 1954 it would appear that the production potential of the trees has been reached and may not change significantly in the next few years.

PROCESSING TUNG NUTS

Estimating production of tung nuts at somewhat over 100,000 tons annually, the United States tung industry can be valued at around 6 million dollars

Table 3.--Estimated number of trees under cultivation, 1956 season 1/

State	Not of bearing age	Of bearing age	Total
	1,000 trees	1,000 trees	1,000 trees
Alabama and Georgia	---	350	350
Florida	1,144	2,350	3,494
Louisiana	706	1,918	2,624
Mississippi	458	7,037	7,495
Total	2,308	11,655	13,963

1/ Based on the rate of change between 1950 and 1954. Census reported farms with 10 or more trees in 1950 but 20 or more in 1954.

Table 4.--Whole tung nuts: Production by States and United States, 1939-57 1/

Year beginning November	Alabama	Florida	Georgia	Louisiana 2/	Mississippi	United States
	Tons	Tons	Tons	Tons	Tons	Tons
1939	20	550	15	150	425	1,160
1940	200	4,700	1,200	1,200	3,700	11,000
1941	350	2,250	650	1,800	3,700	8,750
1942	500	3,700	950	4,000	7,200	16,350
1943	100	700	200	3,260	1,940	6,200
1944	700	7,000	800	7,550	10,630	26,680
1945	1,140	8,400	1,100	10,750	15,690	37,080
1946	1,600	15,000	1,800	15,200	23,800	57,400
1947	800	11,000	900	15,500	25,000	53,200
1948	900	17,500	800	14,000	25,300	58,500
1949	1,900	16,200	1,000	25,200	43,600	87,900
1950	1,000	8,200	400	6,100	20,800	36,500
1951	820	12,200	240	2,900	32,900	49,060
1952	2,800	31,000	300	30,200	67,800	132,100
1953	1,300	28,400	600	21,700	68,000	120,000
1954	2,800	21,600	250	4,900	21,500	51,050
1955	3/	6,200	3/	3/	3/	6,200
1956	1,100	16,500	60	19,000	66,800	103,460
1957	700	16,000	100	13,700	52,100	82,600

1/ Production in terms of air-dried nuts in the husk.
2/ Includes small quantities produced in Texas.
3/ Less than 5 tons.
U. S. Dept. Agr. AMS Crop Reporting Board.

(table 5). Mill capacity, for crushing the nuts, with 13 mills in operation during 1956-57, is far in excess of potential production. Most of the mills were started as adjuncts of extensive orchards planted either by individuals or by organized groups, rather than as independent or commercial ventures. There are, however, a few mills which crush on an independent basis, and most integrated orchard-mills, in addition to their own tung crop, crush tung nuts for other growers.

Table 5.--Whole tung nuts: Supply, disposition, price, and value, in the United States, 1939-57

Year beginning November	Supply			Disposition		Price 1/	Value of production
	Production 1/	Imports	Total	Crushings	Residual	Season average	
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons	Dollars per ton	1,000 dollars
1939	1.2	--	1.2	(1.2)	--	42.20	49
1940	11.0	--	11.0	(11.0)	--	60.00	660
1941	8.7	--	8.7	(8.7)	--	88.30	773
1942	16.4	--	16.4	16.4	--	91.80	1,501
1943	6.2	--	6.2	5.5	0.7	99.00	614
1944	26.7	--	26.7	27.3	-.6	102.00	2,730
1945	37.1	--	37.1	27.5	9.6	98.90	3,667
1946	57.4	--	57.4	45.1	12.3	96.90	5,564
1947	53.2	--	53.2	50.6	2.6	64.90	3,452
1948	58.5	2.7	61.2	50.3	10.9	49.10	2,873
1949	87.9	.3	88.2	83.1	5.1	63.70	5,603
1950	36.5	--	36.5	35.8	.7	111.00	4,034
1951	49.1	.1	49.2	48.5	.7	106.00	5,212
1952	132.1	.5	132.6	129.5	3.1	79.80	10,542
1953	120.0	--	120.0	112.6	7.4	66.80	8,011
1954	51.0	--	51.0	46.6	4.4	59.40	3,032
1955	6.2	.5	6.7	2/	--	64.00	397
1956	103.5	--	103.5	100.2	3.3	53.40	5,527
1957 3/	82.6	--	82.6	79.9	2.7	52.30	4,320

1/ Production and price in terms of air-dried nuts in the husks.
2/ Negligible.
3/ Preliminary.

U. S. Dept. of Agr. AMS Crop Reporting Board, and Bureau of the Census.

The nuts are hulled in disk hullers (field hullers are used in some orchards, leaving the hulls in the orchards and transporting the hulled nuts to the mill) and the hulled kernels are dried, if necessary, to about 10 percent moisture content. They are then ground in an attrition mill and the oil

is obtained by pressing the ground hulled nuts in continuous screw presses. The oil, after extrusion, is filtered and is ready for the market. The press cake or "pomace" contains about 3.5 to 6.0 percent oil. The "foots" contain high quality oil, most of which can be removed by solvent extraction and added to the oil from the presses. 1/ Although the hulls have some value as a mulch unless field hulling is used the hulls are seldom returned to the orchard. At the mill the hulls are either burned outside the mill or burned as a fuel.

The crop is handled between the end of October and the end of April, as is evident from deliveries and crushings as given in tables 6, 7, and 8. The Bureau of the Census reports annual yield of oil, based on reports of crushings from the mills and oil produced (table 8). 2/

MARKETING METHODS

Before 1947, tung nuts were generally sold directly to the mills by the independent growers. Since that time, "custom-milling" or "toll-processing" has become almost universal. Under this practice the grower is guaranteed a certain percentage of the oil in the nuts as received at the mill (usually 86 percent or higher, based on the mill's expected recovery). The grower retains ownership of this percentage of the oil which may be sold by him individually, or as a member of a cooperative sales organization, or by the mill. The grower's toll-processing contract may call for discounts at the end of the season if the mill fails to make the expected recovery and often calls for premiums from the mill if greater than expected recovery is made.

There are no grades or standards set for the quality of tung nuts other than oil content. Returns to the producer from the sale of the tung oil are credited to his account by the processor. 3/ These returns are based on the recovery of the oil from the test of the oil content and the quantity of nuts as delivered to the mill. Hauling charges are paid by the producer. The producer also pays a processing cost based on the total nuts delivered. Some mills return foreign material to the truck or leave any foreign material in the truck and base their processing charge on the net load of nuts.

An example of the return the producer would realize from a ton of nuts, taking into consideration the various charges, follows:

1. Test of oil content at mill = 17 percent.
2. Guaranteed recovery = 86 percent, or 14.62 percent of oil content = 292.4 pounds of oil.

1/ In tung oil processing the term "foots" refers to the residue from the filter press or the settling tank.

2/ The Census takes into account the fact that a part of the crop received at the mills has been hulled, and uses a factor to convert the weight of the hulled nuts back to whole nuts.

3/ Better recoveries of the oil content can usually be made by mills on hulled nuts delivered by producers. The mill in this case generally guarantees greater recoveries to the producer.

Table 6.--Whole tung nuts: Deliveries to mills in the United States, by months, 1943-44 through 1957-58

Year beginning November	November	December	January	February	March	April	May	June	July	Total 1/
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1943	--	1,291	91	1,829	1,438	696	125	--	--	5,470
1944	1,628	2,905	4,858	3,031	4,032	6,904	3,952	2/	2/	27,416
1945	3/4,041	4,096	7,018	6,635	5,289	3,111	1,260	2/	2/	32,354
1946	4,679	9,008	7,114	12,365	3,098	5,268	2,312	2/	2/	45,094
1947	2/	2/	11,440	11,213	10,511	8,562	3,496	2/	2/	50,589
1948	2,878	4,052	14,357	12,634	8,638	4,698	2,420	2/	2/	48,859
1949	11,741	18,142	17,280	15,628	10,623	9,627	2/	2/	--	4/82,808
1950	6,667	8,621	11,960	6,193	2/	2/	--	--	--	56,593
1951	2/	2/	2,751	1,951	1,200	2/	2/	2/	--	67,077
1952	3,089	4,415	24,042	19,514	22,876	8,781	2/	2/	--	90,163
1953	3/14,857	27,488	27,845	22,897	13,570	4,187	2/	2/	--	113,137
1954	13,555	14,027	4,134	10,698	3,915	2/	2/	2/	--	48,698
1955	1,338	2/	1,556	921	2/	2/	--	--	--	4,456
1956	3/21,576	20,129	25,021	2/	11,350	3,154	--	--	--	2/
1957	13,666	2/	13,715	12,491	9,969	2/	--	--	--	2/

1/ When total given is not same as total of months, the difference is the sum of figures not reported by months to avoid disclosure of individual operations.

2/ Not shown to avoid disclosure of individual operations.

3/ Includes small amount of nuts received in October.

4/ Small amounts of nuts received in August and September, probably from 1948 crop.

Table 7.--Whole tung nuts: Crushings at mills in the United States, by months, 1943-44 through 1957-58

Year beginning November	November	December	January	February	March	April	May	June	July	Total 1/
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
1943	--	--	732	1,112	1,210	1,032	1,384	--	--	5,470
1944	--	2/	3,071	3,675	5,529	7,089	5,138	1,122	2/	27,333
1945	2/	3,601	5,524	7,306	5,343	3,424	2,072	933	2/	27,500
1946	2,804	5,309	7,340	8,459	7,545	6,167	4,546	2/	2/	45,094
1947	--	2,871	9,536	9,700	9,883	10,465	6,104	2/	2/	50,589
1948	1,673	3,259	10,935	10,509	10,415	7,299	4,726	900	2/	50,252
1949	6,695	15,530	18,099	14,998	11,745	10,894	4,356	518	2/	83,105
1950	4,143	7,496	10,105	7,427	6,266	2/	2/	--	--	35,837
1951	5,654	2/	2,483	1,380	1,271	2/	2/	--	--	48,500
1952	2/	4,224	23,017	20,764	22,055	14,852	6,811	2/	--	129,500
1953	10,303	25,712	23,234	26,131	18,348	6,586	2,190	2/	--	112,554
1954	4,876	10,712	12,660	12,726	5,589	--	--	--	--	46,563
1955	2/	2/	2/	2/	2/	2/	--	--	--	4/
1956	3/15,573	19,499	24,834	22,163	11,878	6,229	--	--	--	100,176
1957	2/	2/	15,924	13,063	11,181	7,523	--	--	--	79,863

1/ When total given is not same as total of months, the difference is the sum of figures not reported by months, to avoid disclosure of individual operations.

2/ Not shown to avoid disclosure of individual operations.

3/ Includes small amount of nuts crushed in October.

4/ Negligible.

Table 8.--Whole tung nuts crushed, tung oil produced, and yield, in the United States, 1939-57

Year beginning November	Nuts crushed	Oil produced	Yield of oil per ton of nuts
	Thousand tons	Million pounds	Pounds
1939 1/	1.2	(0.4)	(320)
1940 1/	11.0	(3.5)	(320)
1941 1/	8.7	(2.8)	(320)
1942	16.4	5.2	316
1943	5.5	1.9	341
1944	27.3	8.8	321
1945	27.5	9.1	332
1946	45.1	14.4	319
1947	50.6	16.0	316
1948	50.3	17.0	339
1949	83.1	26.8	322
1950	35.8	12.3	343
1951	48.5	14.7	303
1952	129.5	43.4	335
1953	112.6	39.6	352
1954	46.6	15.2	325
1955	2/	2.0	--
1956	100.2	32.0	319
1957 3/	79.9	25.5	319

1/ Amount of nuts crushed was assumed to be the same as that produced. Oil produced was based on 320 pounds per ton of nuts.
2/ Negligible.
3/ Preliminary.

Bureau of the Census and the U. S. Department of Agriculture.

3. Hauling charges = $2.50.
4. Processing charge = $13.00.
5. Premiums at end of season = 2 percent, or 5.85 pounds of oil.
6. Net price of oil = 21.5 cents per pound for 298.25 pounds of oil.

Gross return = $64.12
Cost = 15.50

Net return = $48.62

The mill usually retains the byproducts from the crushings as well as that portion of oil obtained from recoveries over the quantity guaranteed. No value can be given to the hulls except where used as a fuel at the mill. Foots may be subjected to solvent purification but their value per pound is considerably under that of the crude oil.

PROCEDURE

During the 1954-55 harvesting season some 250 loads of tung nuts were sampled at mills from November through February, and during the 1956-57 season some 300 loads were sampled in January and February 1957. Four of the same mills were sampled in each season; however, samples were taken from three other mills as well. Thirteen mills were in operation.

Samples were drawn by Government inspectors and tested by an independent commercial laboratory for oil content, moisture, and amount of foreign material Through these tests researchers were able to ascertain composition of the nuts as received at the mill. Tests were also conducted to show variations in similar samples of the same portion and to enable comparisons of standard sampling with other methods of sampling.

Sampling and testing methods used were in accordance with those of the American Oil Chemists' Society.

During the early development of the tung industry there was little uniformity in the methods used by mills in sampling and testing for oil content of nuts delivered by growers. Following considerable investigation of these problems, the industry in 1948 adopted the tentative standards for sampling and testing developed by the American Oil Chemists' Society. This procedure is known as the standard procedure.

Briefly, the standard procedure requires that small bucketfuls of tung nuts (6" x 6" x 6") be taken from the center of the unloading chute at regular intervals and in sufficient number so that the gross sample for a load fills a 50-pound lard can. The contents are to be kept airtight until opened for testing. 4/ This standard also prescribes the methods to be used to determine oil content.

This procedure has been adopted to a considerable degree by the industry which generally applies it to each load of nuts delivered. Nevertheless, it is recognized in the industry that it is difficult to get an accurate sample of tung nuts and that the sampling error, which is particularly likely to arise when the standard procedure is not followed closely, is one of the principal reasons for significantly different results often obtained by different laboratories in testing samples from the same loads.

4/ Most mills have the samples tested by independent commercial laboratories which require shipment to these locations. The net weight of the sample at the time of sampling must be known by the laboratory.

Smaller samples taken than those required can show greater variation from the average test of the load. This is true, also, of samples not taken uniformly throughout the load. If moisture, broken nuts, foreign material, etc., are not evenly distributed throughout the load, as can occur at the end of the unloading, larger portions or more portions taken at this point can appreciably affect representativeness of the sample as compared to the load.

Errors of sampling are quite possible even when samplers are well qualified for the work. In order to minimize sampling errors, which affect returns to both growers and processors, it is important that the standard method be followed closely.

Inspectors also obtained information from some producers concerning the growing conditions prior to the marketing of the nuts. This information was related to the oil content of the nuts. Samples were taken from loads from many different orchards from the standpoint of growing conditions and other influences that would affect the oil content in the marketing operation.

Samples were not taken from all areas of the tung belt, nor were they taken throughout the entire delivery season to the mills nor in proportion to the total receipts at each mill. Average conditions in the tung belt cannot be accurately ascertained from the data; however, since samples were taken in the eastern and western areas of the belt in about the proportion of production each season, fairly good estimates can be made of these average conditions.

COMPOSITION OF TUNG NUTS

The individual tung nut contains generally 4 or 5 seeds (however, the number may be from 1 to 15). Each seed consists of a kernel enclosed by a thin hard inner hull, and the whole surrounded by a fibrous outer hull about one-fourth inch thick. The average kernel weighs a bit less than 1.5 ounces and about 20 pounds of nuts will occupy around 1 cubic foot of space. The kernels contain all the oil of the nuts.

Oil Content in Relation to Other Parts of Tung Nuts

Tests of the tung nut show the following average composition (on a cleaned dry basis):

	Percent
Kernels	33
Shell	21
Inner hull	7
Outer hull	39

Moisture decreases the percentage of each of the component parts, but not in direct relation to each part.

Thirty-eight samples of tung nuts (each averaging about 15 pounds and containing about 170 nuts) were taken from different loads at several mills during 1955 and analyzed by the component part method. There was no significant relationship, on a dry basis, of the oil content of the kernels to the weight of the kernels. The average weight of the dry kernels was 34.34 percent of the dry nut, and the average percent of oil in the dry kernels was 63.52 percent. The weight of the kernels varied from 23.0 to 41.3 percent of the whole nut on a dry basis. Oil content of the dry kernels varied from 56.4 to 68.6 percent. The oil content is shown to vary over a wide range, even without the effects of a variable moisture content.

The nuts mature and drop from the tree from late September to early November. At that time they may contain as much as 60 percent moisture by weight. Moisture decreases to about 30 percent during the first few weeks if the nuts are left on the ground. During this time the nuts may be harvested, placed in burlap bags, and stored for further drying in the crotch of the trees. Or they may be harvested and placed in bins under cover, where further drying will occur. However, in recent years, more nuts are being left on the ground until they are transported to the mill. The bulk of the harvest reaches the mills in midwinter and deliveries are usually completed during April. Foreign material in the form of hull particles, leaves, twigs, soil, sand, etc., is picked up during harvesting and becomes a part of the load, as delivered to the mill.

OIL CONTENT OF SAMPLES DURING THE TWO SEASONS OF 1954-55 AND 1956-57

During the 1956-57 season, loads of nuts received at the mills tested as low as 8.1 percent in oil and as high as 25.3 percent (table 9). During the 1954-55 season this range was from 9.0 percent to 22.3 percent (table 10). If the oil tested 9 percent, a ton of the nuts, with oil at 22 cents, would be valued at $35.64; at 22.3 percent, a ton would be worth $111.32. The majority of the loads at the mills varied in value from $66.00 to $86.24 per ton of nuts. (All values as given are based on 100 percent recovery of the oil by the processor. Most mills guarantee only 86 percent.)

There was no significant difference in the oil content on a cleaned dry basis in the two seasons. If foreign material is taken into consideration in the samples taken in 1954-55, average oil content on a cleaned dry basis would be 22.35 percent in test during 1954-55 compared with 22.33 percent in 1956-57.

Oil content as received at the mills, however, was slightly lower in 1956-57 than in 1954-55. Most of this decrease in oil content of 0.66 percent can be accounted for by the increase in moisture content--from 19.93 percent to 22.64 percent, or a 2.7-percent increase. Moisture increase accounts for all of the oil content decrease except 0.18 percent. Foreign material increase could account for this additional small amount (foreign material was not determined in 1954-55), as wetter nuts would have a tendency to be higher in foreign material.

The distribution of oil content during the two seasons is shown in figures 1 through 4.

Table 9.--Whole tung nuts: Variations of oil, moisture, and foreign material content of samples taken during 1956-57

Item	All samples					60 percent of samples			
	Samples	Lowest test	Highest test	Difference between highest and lowest test	Average test	Samples	Lowest test	Highest test	Difference between highest and lowest test
	Number	Percent	Percent	Percent	Percent	Number	Percent	Percent	Percent
Oil content on a cleaned dry basis	217	14.6	29.2	14.6	22.33	130	21.5	25.0	3.5
Oil content as received at mills	205	8.1	25.3	17.2	16.80	123	15.0	19.6	4.6
Moisture content as received at mills	205	5.0	42.7	35.7	22.64	123	12.5	24.0	11.5
Foreign material content as received at mills	205	.1	12.1	12.0	2.35	123	.3	2.6	2.3

Table 10.--Whole tung nuts: Variations of oil and moisture content of samples taken during 1954-55

Item	All samples					60 percent of samples			
	Samples	Lowest test	Highest test	Difference between highest and lowest test	Average test	Samples	Lowest test	Highest test	Difference between highest and lowest test
	Number	Percent	Percent	Percent	Percent	Number	Percent	Percent	Percent
Oil content on a dry basis 1/	248	15.2	26.9	11.7	2/21.82	149	21.0	24.0	3.0
Oil content as received at mills	248	9.0	22.3	13.3	17.46	149	16.0	19.1	3.1
Moisture content as received at mills	234	10.2	49.1	38.9	19.93	140	16.5	23.5	7.0

1/ During 1954-55 only a few samples were tested for foreign material. All tests reported here are on a dry basis only, and not a cleaned dry basis--cleaning would have removed foreign material. Had foreign material been known and taken into account, all tests would have been higher, i.e., on a cleaned dry basis.

2/ If foreign material was as high as in 1956-57, i.e., 2.35 percent, the average test on a cleaned dry basis would have been 22.35 percent.

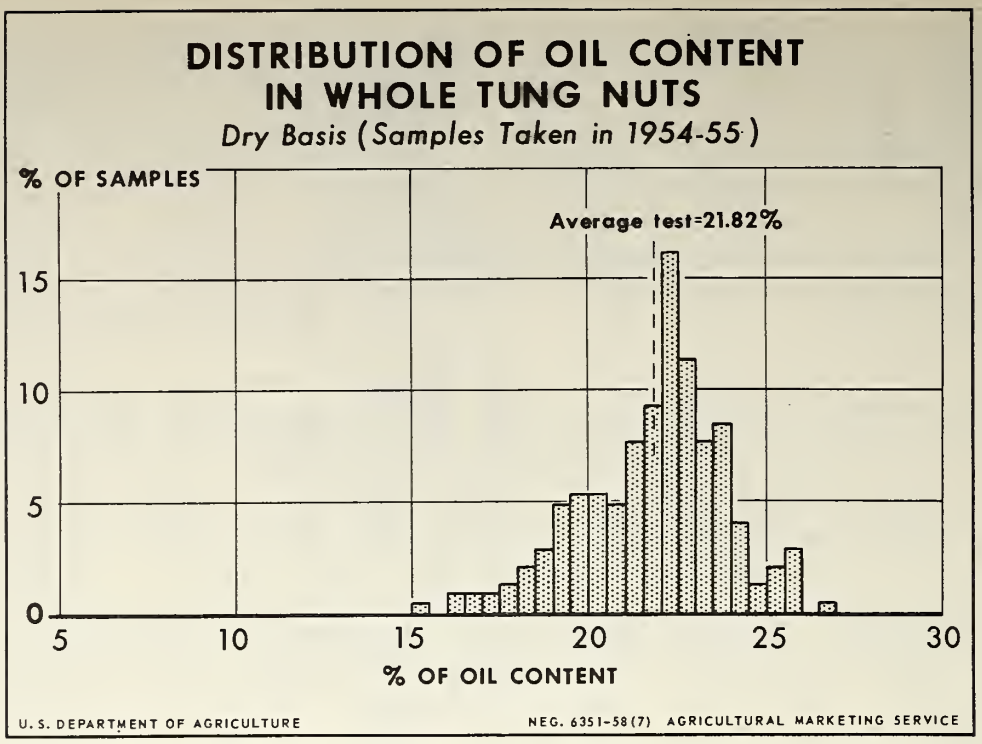

Figure 1

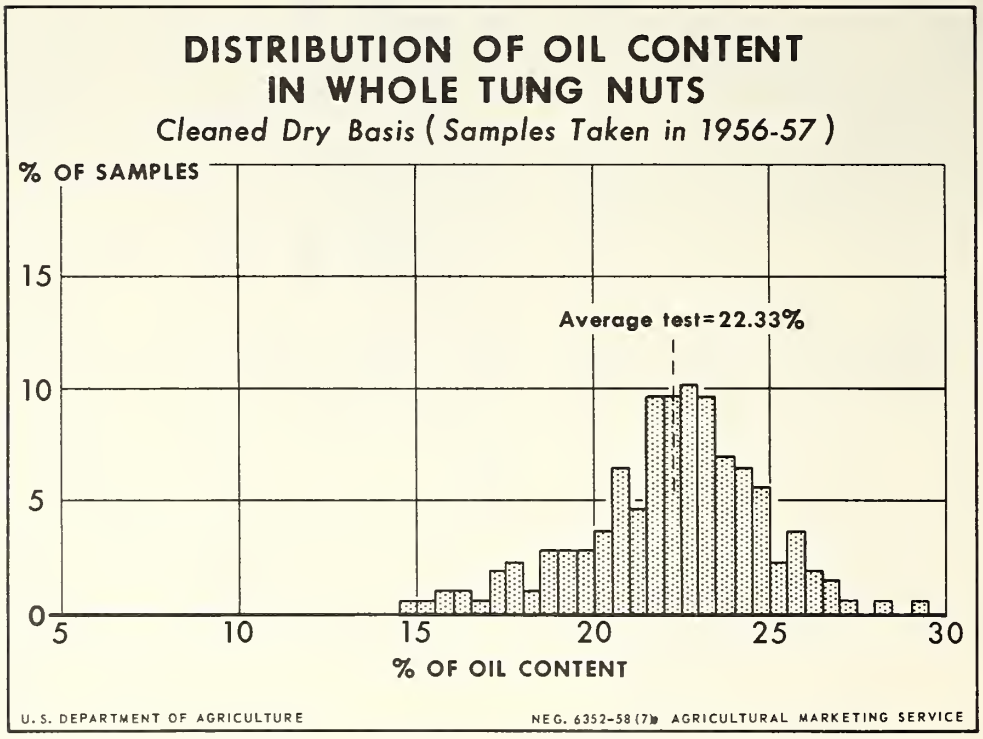

Figure 2

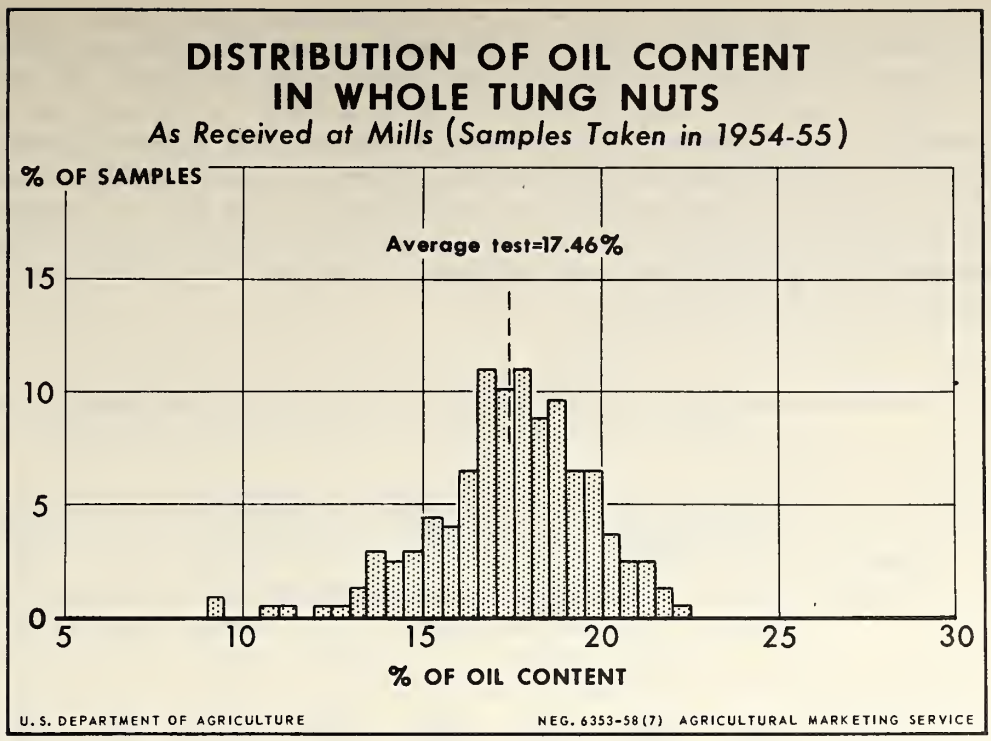

Figure 3

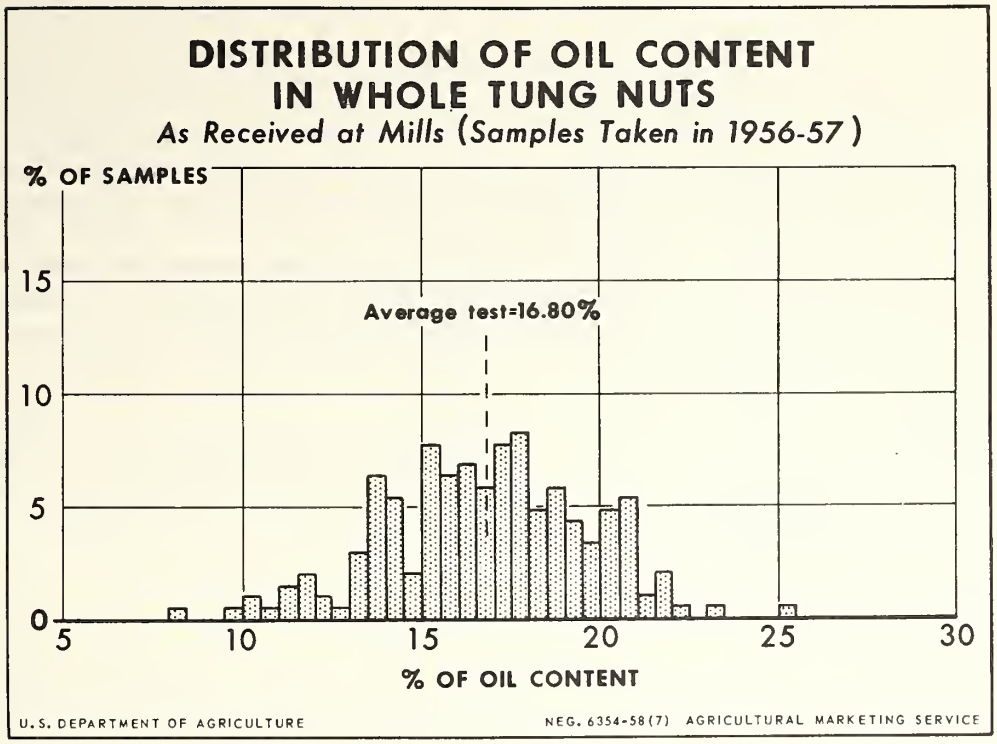

Figure 4

The method of storage of the nuts at the orchard could account for the increased moisture content in 1956-57 as compared to 1954-55, as shown in table 11. When the nuts were left on the ground, moisture content was higher in both seasons than when the nuts were stored in the crotch of the trees or stored in bins. Furthermore, nuts stored on the ground showed greater moisture content during the 1956-57 season than the 1954-55 season. Also, a greater percentage of the nuts were stored on the ground in the 1956-57 season. Nuts stored in bins during 1956-57 contained almost 7.5 percent less moisture than nuts stored on the ground, and nuts stored in the crotch of the trees contained almost 4.0 percent less.

Table 11.-- Whole tung nuts: Relationship of moisture content and method of storage during seasons of 1954-55 and 1956-57

Season	Samples taken	Method of storage: Ground: Samples	Ground: Percentage of total	Ground: Average moisture	Crotch of trees: Samples	Crotch of trees: Percentage of total	Crotch of trees: Average moisture	Bins: Samples	Bins: Percentage of total	Bins: Average moisture
	No.	No.	Pct.	Pct.	No.	Pct.	Pct.	No.	Pct.	Pct.
1954-55	234	126	54	20.15	65	28	19.89	43	18	19.34
1956-57	178	115	65	24.14	51	29	20.34	12	6	16.76

The amount of foreign material received at the different mills during the 1956-57 season varied among mills on an average from 0.1 percent to 12.0 percent. Even when nuts were received at the mills from about the same general area and had been stored under generally similar conditions, there were differences in foreign material. Further study would be necessary to draw any conclusions as to the reasons for these differences at the mills. There are, however, some indications that the method of unloading the nuts has an effect on the amount of the foreign material in the sample from the load.

A comparison of the mills using the gravity dump method with those using pneumatic unloading showed that, in the former, foreign material varied from a minimum of 0.1 percent test in the samples to less than 2.5 percent, whereas the latter had a maximum test as high as 12.1 percent. The average test of foreign material at those mills with gravity dump unloading was 0.81 percent as compared to 2.67 percent where pneumatic unloading was used. It could be that pneumatic unloading gives a more representative sample by distributing all the foreign material in the load more evenly as the nuts are drawn from the load, whereas, with the gravity method, more foreign material (especially heavier material, such as sand and gravel) remains after the load is dumped.

This heavier foreign material may or may not get in the last portions of the sample. If it did not, the test would be lower than actually was representative.

From this study and from reports from the Census Bureau, an estimate can be made of average recoveries of oil during the two seasons.

The U. S. Bureau of the Census has reported a yield of 325 pounds of tung oil per ton of nuts for the belt in 1954-55. In 1956-57 the yield was reported as 319 pounds per ton of nuts. If the methods used in processing the nuts at the mills were equally efficient in these seasons, the oil content of the nuts in the later season was 98.15 percent as much as in the earlier season. Individual recoveries and oil content of the nuts as received at the mills are not reported to the Census.

This study shows that, based on oil content at the mills of 17.46 percent in 1954-55 and 16.80 percent in 1956-57, the oil content of nuts produced in 1956-57 was 96.22 percent of the oil content of the 1954-55 crop. This is somewhat lower than the 98.15 percent as calculated from the Census yields given above.

This study has taken into account the amount of foreign material in the samples when oil content as received at the mills is recorded. The reports sent to the Census by the mills, from which yield for the industry is calculated, do not state whether foreign material has been excluded or not, in recording the amount of nuts processed. It is believed that most mills report nuts processed on the basis of no foreign material in the nuts.

If foreign material is excluded from the data in this study, the average oil content as received at the mills was 17.88 percent in 1954-55 (using the same foreign material content as in 1956-57) and 17.20 percent in 1956-57. By using the yields of the Census in these 2 seasons, average recovery at the mills in 1954-55 would be 90.88 percent and 92.73 percent in 1956-57.

The price-support program uses an oil content at the mills of 18.5 percent and recovery by the mills of 86.0 percent. This calculates to 15.91 percent oil content as a basis for the purchase of oil ($13.00 per ton for processing is allowed for the tung nuts). Although oil content was lower than 18.5 percent during both seasons of the study, recovery of oil by the mills appears to be higher than 86.0 percent. During 1954-55, with an oil content of 17.88 percent and a recovery of 90.88 percent, this calculates to 16.25 percent and in 1956-57, 15.94 percent by the same method of calculation.

OIL CONTENT OF LOADS OF NUTS FROM THE SAME ORCHARD

Although loads of nuts from over 200 different orchards varied in oil test by as much as 17.2 percent during the 1956-57 season, the variation of more than one load from the same orchard was only 7.1 percent. Loads from 21

orchards were sampled in groups of from 2 to 6 loads from each of these orchard and the tests of each orchard put on the same basis to show the variation as if all 73 samples were taken from the same orchard. The results (table 12) show that, although the extreme variation of any 2 samples could be as much as 7.1 percent, most of the samples show a variation of only 1.8 percent.

Knowing the total quantity of oil that is produced from an orchard is important to the producer. There is no way to arrive at a good estimate of this unless every load from the orchard is tested. A 10-ton load could differ in test from any other load out of the same orchard by as much as 7.1 percent in oil content, or 1,420 pounds of oil. This would amount to $312.40 with oil at 22 cents per pound. This could be a gain or a loss to the producer. The more loads from the producer, with a sample taken of each, the more the possibility of all the tests averaging out to the true average test. For a man who produces only a few loads of nuts, the possibility that the average test of the loads will be the true average of his production is less than for a large-quantity producer.

OIL CONTENT OF SAMPLES OF NUTS FROM THE SAME LOAD

Although loads of nuts from the same orchard differed in test by as much as 7.1 percent in oil content at the mills, the variation in test of more than 1 sample from the same load was only 3.3 percent. The results given in table 13 show that, although the extreme variation of any 2 samples could be as much as 3.3 percent, most of the samples show a variation of only 0.7 percent.

Any sample taken which represents the oil content of the load can vary from the true oil content by as much as 2.0 percent. In a 10-ton load of nuts with oil at 22 cents per pound, this difference would amount to $88.00. If this test were lower, there would be a loss to the producer.

DIFFERENCES IN OIL CONTENT OF SPLIT PORTIONS DRAWN FOR STANDARD SAMPLES

A portion of nuts large enough to be equally divided for 2 samples of 15 to 20 pounds each was drawn from the load by standard sampling procedure. Either of these split portions were used as a sample representative of the load. A study was made of the differences in test of each of these split portions for 10 portions drawn from each of 5 loads of nuts. Each difference in test of each of the 2 samples was put on the same basis to show the variation in differences as if all the tests were made from the same load instead of 5 different loads.

The results as given in table 14 show that in 36 out of the total of 49 portions (one test missing), the difference in the 2 split portions was less than 0.5 percent in the test of oil content at the mills, and the highest difference for all the split portions was 1.8 percent. This indicates that of the

Table 12.--Whole tung nuts: Variations of oil, moisture, and foreign material content of samples taken from different loads of the "same" orchard 1/

Item	All samples					60 percent of samples			
	Samples	Lowest test	Highest test	Difference between highest and lowest test	Average test	Samples	Lowest test	Highest test	Difference between highest and lowest test
	Number	Percent	Percent	Percent	Percent	Number	Percent	Percent	Percent
Oil content on a cleaned dry basis	73	19.3	26.4	7.1	23.32	44	22.5	24.5	2.0
Oil content as received at mills	73	13.8	20.9	7.1	18.00	44	17.5	19.3	1.8
Moisture content as received at mills	73	13.5	29.1	15.6	21.79	44	20.0	23.2	3.2
Foreign material content as received at mills	73	1.0	3.9	2.9	2.00	44	1.0	2.1	1.1

1/ Samples taken from 21 orchards, and tests of samples from each orchard adjusted to the average test of all samples. Samples taken from 2 loads from 7 orchards, 3 loads from 5 orchards, 4 from 3 orchards, 5 from 4 orchards, and 6 from 2 orchards.

Table 13.--Whole tung nuts: Variations of oil, moisture, and foreign material content of samples taken from the "same" load 1/

Item	All samples					60 percent of samples			
	Samples	Lowest test	Highest test	Difference between highest and lowest test	Average test	Samples	Lowest test	Highest test	Difference between highest and lowest test
	Number	Percent	Percent	Percent	Percent	Number	Percent	Percent	Percent
Oil content on a cleaned dry basis	100	20.6	23.2	2.6	22.05	60	21.7	22.3	0.6
Oil content as received at mills	99	14.7	18.0	3.3	15.99	60	15.8	16.5	.7
Moisture content as received at mills	99	17.1	27.7	10.6	21.83	60	21.0	22.2	1.2
Foreign material content as received at mills	100	4.2	8.5	4.3	5.97	60	5.3	6.7	1.3

1/ Samples taken from 5 loads, and tests of samples from each load adjusted to the average test of all samples. Ten portions were taken from each load and each divided into 2 parts to get 20 samples from each load--each of which is a sample according to standard methods.

Table 14.--Whole tung nuts: Variations of differences in tests of oil and moisture content of split portions taken by standard sampling methods 1/

Item	All split portions				Average test of all samples	Specified range of difference of split portions					
						0 - 0.5% difference		0.6 - 1.0% difference		Above 1.0% difference	
	Portions	Lowest difference	Highest difference	Range of difference		Portions	Percentage of portions	Portions	Percentage of portions	Portions	Percentage of portions
	No.	Pct.	Pct.	Pct.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Oil content, cleaned dry basis	50	0	1.8	1.8	22.05	33	66.0	15	30.0	2	4.0
Oil content, at mills	49	0	1.8	1.8	15.98	36	73.5	10	20.4	3	6.1
Moisture content, at mills	49	0	5.3	5.3	21.82	27	55.1	13	26.5	9	18.4

1/ Standard sampling methods (AOCS) require a portion from the load taken throughout the unloading, which portion is split two ways--either split portion used as a sample of the load. Ten such portions were taken from five loads and all tests adjusted to the average of all samples. Each portion is made up of two split portions, both of which have been tested to obtain differences in tests of the split portions.

2 samples which make up the portion drawn from the load, either sample could be as much as 0.9 percent below or above the average test of the oil content in the load of nuts. In a 10-ton load of nuts, this amounts to $39.60 in terms of oil at 22 cents per pound.

See footnote for a different sampling procedure. 5/

Average tests of oil content of the whole tung nuts showed wide variation of from 14.6 to 29.2 percent. This difference was found in the analysis of 217 samples taken at different tung oil mills throughout the tung area. However, the majority of the samples varied only 3.5 percent, or from 21.5 to 25.0 percent oil content on a cleaned dry basis. The variation in oil content of nuts from samples taken from the same orchard showed a maximum difference of only 6.8 percent between the highest and lowest analysis, with the majority of the samples showing only 1.9 percent. This variation was further reduced when samples from the same loads were compared (table 16). The variation in oil content from the same samples described above when analyzed on an "as received" basis rather than a cleaned dry basis is shown in table 17.

The variation in moisture content of 205 samples taken from various mill locations throughout the tung area ranged from a low of 5 percent to a high of 42.7 percent. However, the majority of the samples ranged from 12.5 to 24.0 percent moisture content. This wide range in moisture content was greatly reduced when samples from the same orchard were compared (majority of samples with 3.3 percent difference) and still further reduced when samples from the same load were compared. The average moisture difference for the majority of these samples was only 1.2 percent (table 18).

The amount of foreign material in the 205 samples varied from 0.1 percent to 12.1, with the majority of the samples showing a difference of only 2.3 percent. Samples from the same orchard showed a foreign material maximum difference of 3.5 percent, and from the same load 1.9 percent (table 19).

FIELD HULLING OF TUNG NUTS

Hulling the nuts in the orchards and taking only the hulled nuts to the mill was tried on a limited basis by some growers a few years ago. The method has not been used extensively, due to the cost of the equipment, its lack of mechanical efficiency, and the skilled labor needed in its operation. The

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5/ Some data have been obtained to show variations in the oil content at the mills, when a method of sampling is used other than that given in standard procedure (samples taken at the chute of the truck while unloading). Four loads of nuts were sampled by drawing portions at the front, center, and rear of the load. In view of the limited number of loads sampled by this procedure, the results cannot be considered conclusive and can only be used as an estimate. The results are shown in table 15 and indicate that the variation of the oil content at the 3 locations in the load is not significantly different from samples taken by the standard procedure.

Table 15.--Whole tung nuts: Comparisons of variations in oil, moisture, and foreign material content of standard samples with portions taken at 3 specified locations in 4 loads 1/

Item	Oil content (cleaned dry basis)			Oil content (as received at mills)			Moisture content (at mills)			Foreign material content at mills		
	Lowest test	Highest test	Difference between highest and lowest test	Lowest test	Highest test	Difference between highest and lowest test	Lowest test	Highest test	Difference between highest and lowest test	Lowest test	Highest test	Difference between highest and lowest test
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
All samples: 2/												
Standard	20.9	23.4	2.5	15.4	18.9	3.5	17.7	28.7	11.0	1.6	3.5	1.9
Specified locations	21.7	23.1	1.4	16.3	17.7	1.4	21.3	23.5	2.2	1.5	4.0	2.5
60 percent of samples:												
Standard	21.8	22.7	.9	16.4	17.1	.7	21.9	23.1	1.2	2.0	2.5	.5
Specified locations	21.8	22.6	.8	16.6	17.3	.7	22.0	23.4	1.4	1.5	2.1	.6

1/ Standard samples taken according to approved methods of the American Oil Chemists' Society--10 portions from each of 5 loads and divided into 2 parts to give 20 samples from same load (one sample missing as received at mills).

The locations specified from which portions were taken are front, center, and rear of loads.

All tests adjusted to average tests in area, as follows: Oil content of 22.33 percent on cleaned dry basis. As received at mills: Oil content of 16.80 percent, moisture content of 22.64 percent, and foreign material content of 2.35 percent.

2/ A total of 100 standard samples were tested for oil content on a cleaned dry basis. Only 99 samples were tested at the laboratory to determine their composition as received at mill. A total of 12 portions were taken at specified locations.

Table 16.--Whole tung nuts: Comparisons of variations in oil content, on a cleaned dry basis of samples taken at different sources 1/

Item	All samples					60 percent of samples			
	Samples	Lowest test	Highest test	Difference between highest and lowest test	Average test	Samples	Lowest test	Highest test	Difference between highest and lowest test
	Number	Percent	Percent	Percent	Percent	Number	Percent	Percent	Percent
In the area	217	14.6	29.2	14.6	22.33	130	21.5	25.0	3.5
In the orchard 2/.	73	18.5	25.3	6.8	22.33	44	21.8	23.7	1.9
In the load 3/....	100	20.9	23.4	2.5	22.33	60	21.8	22.7	.9

1/ Tests of samples "in the orchard" and "in the load" are adjusted to the average test of the area.
2/ Samples taken from 21 orchards, and tests of samples from each orchard adjusted to the average test of all samples. Samples taken from 2 loads from 7 orchards, 3 loads from 5 orchards, 4 from 3 orchards, 5 from 4 orchards, and 6 from 2 orchards.
3/ Samples taken from 5 loads, and tests of samples from each load adjusted to the average test of all samples. Ten portions taken from each load and each divided into 2 parts to get 20 samples from each load--each of which is a sample according to standard methods.

Table 17.--Whole tung nuts: Comparisons of variations in oil content, as received at mills, of samples taken at different sources 1/

Item	All samples					60 percent of samples			
	Samples	Lowest test	Highest test	Difference between highest and lowest test	Average test	Samples	Lowest test	Highest test	Difference between highest and lowest test
	Number	Percent	Percent	Percent	Percent	Number	Percent	Percent	Percent
In the area	205	8.1	25.3	14.6	16.80	123	15.0	19.6	4.6
In the orchard 2/.	73	12.5	19.5	7.0	16.80	44	16.0	17.9	1.9
In the load 3/....	99	15.4	18.9	3.5	16.80	60	16.4	17.1	.7

1/ Tests of samples "in the orchard" and "in the load" are adjusted to the average test of the area.
2/ Samples taken from 21 orchards, and tests of samples from each orchard adjusted to the average test of all samples. Samples taken from 2 loads from 7 orchards, 3 loads from 5 orchards, 4 from 3 orchards, 5 from 4 orchards, and 6 from 2 orchards.
3/ Samples taken from 5 loads, and tests of samples from each load adjusted to the average test of all samples. Ten portions taken from each load and each divided into 2 parts to get 20 samples from each load--each of which is a sample according to standard methods.

Table 18.--Whole tung nuts: Comparisons of variations in moisture content, as received at mills, of samples taken at different sources 1/

Item	All samples					60 percent of samples			
	Samples	Lowest test	Highest test	Difference between highest and lowest test	Average test	Samples	Lowest test	Highest test	Difference between highest and lowest test
	Number	Percent	Percent	Percent	Percent	Number	Percent	Percent	Percent
In the area	205	5.0	42.7	35.7	22.64	123	12.5	24.0	11.5
In the orchard 2/	73	14.1	30.2	16.1	22.64	44	20.8	24.1	3.3
In the load 3/	99	17.7	28.7	11.0	22.64	60	21.9	23.1	1.2

1/ Tests of samples "in the orchard" and "in the load" are adjusted to the average test of the area.
2/ Samples taken from 21 orchards, and tests of samples from each orchard adjusted to the average test of all samples. Samples taken from 2 loads from 7 orchards, 3 loads from 5 orchards, 4 from 3 orchards, 5 from 4 orchards, and 6 from 2 orchards.
3/ Samples taken from 5 loads, and tests of samples from each load adjusted to the average test of all samples. Ten portions taken from each load and each divided into 2 parts to get 20 samples from each load--each of which is a sample according to standard methods.

Table 19.--Whole tung nuts: Comparisons of variations in foreign material content, as received at mills, of samples taken at different sources 1/

Item	All samples					60 percent of samples			
	Samples	Lowest test	Highest test	Difference between highest and lowest test	Average test	Samples	Lowest test	Highest test	Difference between highest and lowest test
	Number	Percent	Percent	Percent	Percent	Number	Percent	Percent	Percent
In the area	205	0.1	12.1	12.0	2.35	123	0.3	2.6	2.3
In the orchard 2/	73	1.1	4.6	3.5	2.35	44	1.6	2.6	1.0
In the load 3/	100	1.6	3.5	1.9	2.35	60	2.0	2.5	.5

1/ Tests of samples "in the orchard" and "in the load" are adjusted to the average test of the area.
2/ Samples taken from 21 orchards, and tests of samples from each orchard adjusted to the average test of all samples. Samples taken from 2 loads from 7 orchards, 3 loads from 5 orchards, 4 from 3 orchards, 5 from 4 orchards, and 6 from 2 orchards.
3/ Samples taken from 5 loads, and tests of samples from each load adjusted to the average test of all samples. Ten portions taken from each load and each divided into 2 parts to get 20 samples from each load--each of which is a sample according to standard methods.

breakage of the shells causes loss of some of the kernels, as well as loss of oil by deterioration of the kernels from exposure to the atmosphere. It would appear that leaving the bulky hulls in the field would reduce the cost of handling and transporting the tung nuts. However, no data are available as to the cost of this field operation. In evaluating these operations, consideration should be given to the additional cost to the producer of field hulling and the possible loss in oil content of cracked and broken tung nuts.

The weight of the hulled nuts is about one-half the weight of the whole nuts. Furthermore, the percentage of moisture is much lower in hulled nuts than in the whole nuts before hulling. The hulls of some 38 samples tested in the project retained from 65 to 85 percent of the total moisture of the original whole nuts. The relationship of moisture in the hulls and the hulled nuts is shown in figure 5. On samples of whole nuts ranging in moisture content from 12 to 40 percent, the hulled nuts varied from 5 percent to 12 percent. The nuts could be hulled directly from ground storage at convenient times for hauling and receiving at the mills. No hulling need be done at the mills, and far less moisture would need to be removed before processing.

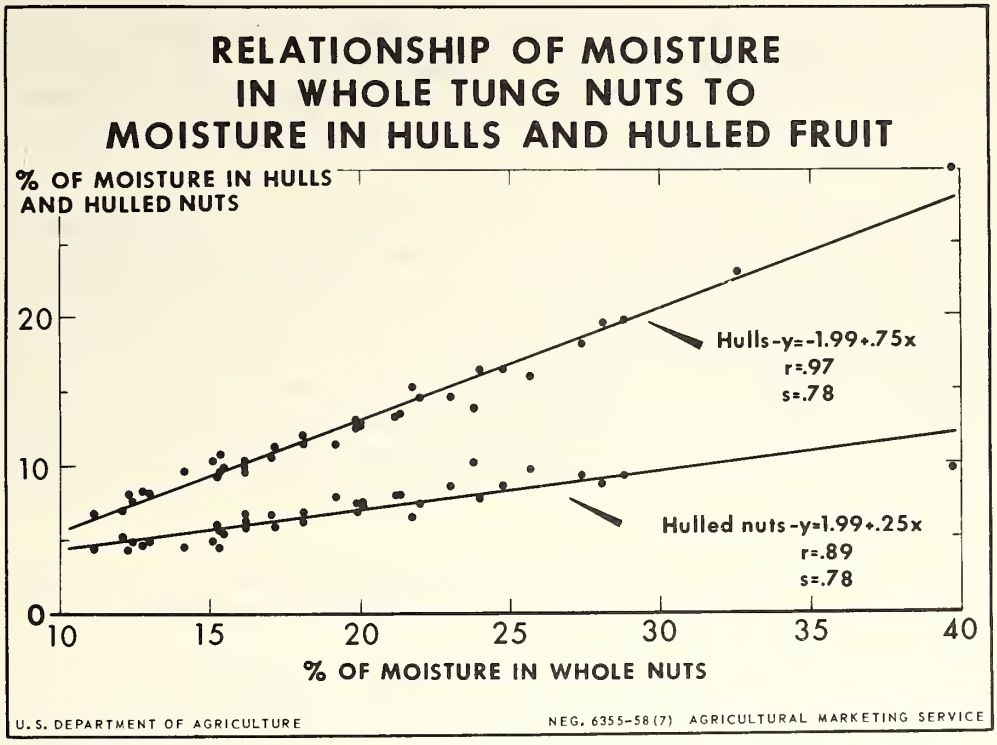

Figure 5

REDUCING COSTS TO PRODUCER

Efficient mechanization is a vital need in harvesting and preparing tung nuts for market. Some progress is now being made with mechanical harvesting but improvements in field hulling equipment are needed to reduce the producer's costs of marketing. A small amount of moisture in the whole nuts or hulled nuts is needed at the mill for efficient processing; however, excess moisture costs the producer higher hauling and processing charges. The mill may assume the costs of handling some of this added moisture but the processor still pays for part of it.

The present methods of reducing the moisture content of the nuts at the orchard are far from satisfactory. Bagging the nuts and storing in the trees, as well as bin storage, is costly. Leaving the nuts on the ground may be even more costly because of higher moisture in the nuts, although there may be no alternative for this, especially with smaller producers. As an example, the additional 2.7 percent moisture in the nuts in 1956-57 over 1954-55, due to ground storage, cost producers on a total crop of 50,000 tons over $20,000. This assumes hauling at $2.50 and processing at $13.00 per ton.

Bin storage may be too costly even for the large producer, but the reduction in moisture content of the nuts is significant. If we assume that all nuts in bins would have decreased in moisture to the extent the data showed for nuts in 1956-57, for 50,000 tons of nuts custom-milled, producers storing in bins would save over $50,000.

Efficient mechanical field hulling would mean even greater possible savings in transportation and processing. If the tung farmer produced 50 tons of nuts in a season, he would save $62.50 in hauling charges and reduce his processing costs. Even with 40 percent moisture in the original whole nuts, the hulled nuts hauled to the mill would only contain around 12 percent moisture. With hulling not necessary at the mill and only a small amount of moisture to be removed by the mill, the processor can reduce his processing charge and guarantee a much higher rate of recovery. These savings can be significant. (At present the practice of field hulling has not been extensive enough to provide any data.)

Mechanical harvesting and field hulling, when perfected, involve expensive equipment. The small producer could not justify the investment with his volume.

The large producer, particularly at distances requiring long hauls to the mill, has made significant savings by the use of hulling equipment. Portable hulling equipment has not proven economically successful. A cooperative use of hulling equipment at one location would only be successful for a number of small producers located near each other, and all at some distance from the mill.

APPENDIX

The following tables 20 through 23 contain statistical data pertaining to the analysis of the tung nuts including the distribution of oil, moisture, and foreign material content for the tung area in both seasons, the different loads, specified locations in loads, standard samples, and split portions of standard samples. Many of these data have not been included in the text but are given here for use as further detailed reference material.

Table 20.--Whole tung nuts: Variations of selected factors of oil content, on the cleaned dry basis from samples taken at different sources

Source	Samples taken	Lowest test	Highest test	Difference between highest and lowest test	Median	Mode	Average	Distribution about the average: Standard deviation	Distribution about the average: Coefficient of variation
	Number	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Different orchards during 1954-55 season ..	248	15.2	26.9	11.7	22.2	22.35	1/21.82	2.06	9.43
Different orchards during 1956-57 season ..	217	14.6	29.2	14.6	22.8	22.81	22.33	2.46	11.04
Different loads on basis of an orchard 2/	73	19.3	26.4	7.1	23.3	23.27	23.32	1.44	6.19
Specified locations in loads on basis of a load 3/	12	21.8	23.1	1.3	22.3	22.25	22.42	.52	2.32
Standard samples on basis of a load 4/	100	20.6	23.2	2.6	22.0	22.11	22.05	.48	2.18
Split portions for standard samples on basis of a load 5/	100	21.2	22.9	1.7	22.0	22.08	22.05	.28	1.37

1/ During 1954-55 only a few samples were tested for foreign material. All tests reported here are on the basis that foreign material was part of the rest of the composition of the nuts other than moisture and oil; therefore, all values in columns 2, 3, 5, 6, and 7 would be greater if foreign material had been known. As an example, if the same foreign material was present as in 1956-57, the average test would be 22.34 percent in column 7.

2/ Two samples each from 7 loads, 3 from 5, 4 from 3, 5 from 4, and 6 from 2 adjusted around the average of all 21 loads.

3/ Samples from the front, center, and rear of 4 loads adjusted around the average of all 4 loads.

4/ Twenty standard samples from 5 loads by taking standard portions and splitting, adjusted around the average of all 5 loads.

5/ High and low test of each split portion of above, adjusted around the average of all 5 loads.

Table 21.--Whole tung nuts: Variations of selected factors of oil content at mills, from samples taken at different sources

Source	Samples taken	Lowest test	Highest test	Difference between highest and lowest test	Median	Mode	Average	Distribution about the average: Standard deviation	Distribution about the average: Coefficient of variation
	Number	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Different orchards during 1954-55 season	248	8.96	22.31	13.35	17.60	17.70	17.46	2.14	12.25
Different orchards during 1956-57 season	205	8.10	25.28	16.18	16.91	17.44	16.80	2.81	16.70
Different loads on basis of an orchard 1/	73	13.79	20.92	7.13	18.10	18.32	18.00	1.34	7.43
Specified locations in loads on basis of a load 2/	12	18.15	19.32	1.17	18.71	3/	18.73	.43	2.31
Standard samples on basis of a load 4/	99	14.68	17.97	3.29	16.06	16.08	15.99	.52	3.23
Split portions for standard s mples on basis of a load 5/	98	15.11	16.87	1.76	16.05	15.98	15.98	.29	1.81

1/ Two samples each from 7 loads, 3 from 5, 4 from 3, 5 from 4, and 6 from 2, adjusted around the average of all 21 loads.

2/ Samples from the front, center, and rear of 4 loads adjusted around the average of all 4 loads.

3/ No mode evident--no tendency for concentration at any one point.

4/ Twenty standard samples from 5 loads by taking 10 standard portions and splitting (1 missing) adjusted around the average of all 5 loads.

5/ High and low test of each split portion of above (2 missing) adjusted around the average of all 5 loads.

Table 22.--Whole tung nuts: Variations of selected factors of moisture content at mills, from samples taken at different sources

Source	Samples taken	Lowest test	Highest test	Difference between highest and lowest test	Median	Mode	Average	Distribution about the average: Standard deviation	Distribution about the average: Coefficient of variation
	Number	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Different orchards during 1954-55 season ..	248	10.2	49.1	38.9	19.15	1/	2/19.93	5.94	29.81
Different orchards during 1956-57 season ..	178	5.0	42.7	37.7	21.24	3/18.55	22.56	7.38	32.69
Different loads on basis of an orchard 4/.....	73	13.5	29.1	15.6	21.97	21.63	21.79	2.67	12.26
Specified locations in loads on basis of a load 5/	12	14.9	16.5	1.6	15.83	1/	15.85	.44	2.79
Standard samples on basis of a load 6/	99	17.1	27.7	10.66	21.78	7/21.71	21.81	.40	1.86
Split portions for standard samples on basis of a load 8/	98	19.2	24.5	5.3	21.83	7/21.89	21.82	.82	3.76

1/ No mode evident. 2/ During 1954-55 only a few samples were tested for foreign material. All tests reported here are on the basis that foreign material was part of the rest of the composition of the nuts other than moisture and oil; therefore, all values in columns 2, 3, 5, 6, and 7 would be greater if foreign material had been known. As an example, if the same foreign material was present as in 1956-57, the average test would be 20.4 percent in column 7. 3/ Not a precise mode--some concentration at other tests. 4/ Two samples each from 7 loads, 3 from 5, 4 from 3, 5 from 4, and 6 from 2, adjusted to around the average of all 21 loads. 5/ Samples from the front, center, and rear of 4 loads adjusted around the average of all 4 loads. 6/ Twenty standard samples from 5 loads by taking 10 standard portions and splitting (1 missing) adjusted around the average of all 5 loads. 7/ Mode only approximated--concentration over a greater area of tests. 8/ High and low test of each split portion of above (2 missing) adjusted around the average of all 5 loads.

Table 23.--Whole tung nuts: Variations of selected factors of foreign material content at mills, from samples taken at different sources

Source	Samples taken	Lowest test	Highest test	Difference between highest and lowest test	Median	Mode	Average	Distribution about the average: Standard deviation	Distribution about the average: Coefficient of variation
	Number	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Different orchards during 1956-57 season ..	205	0.1	12.1	12.0	1.85	1/	2.35	1.86	79.10
Different loads on basis of an orchard 2/	73	1.0	3.9	2.9	1.94	1/	2.00	.70	35.05
Specified locations in loads on basis of a load 3/	12	.4	1.1	.7	.53	1/	.63	.25	39.03
Standard samples on basis of a load 4/	50	4.1	8.5	4.4	5.88	5.82	5.95	.88	14.71

1/ No mode evident.
2/ Two samples each from 7 loads, 3 from 5, 4 from 3, 5 from 4, and 6 from 2, adjusted around the average of all 21 loads.
3/ Samples from the front, center, and rear of 4 loads adjusted around the average of all 4 loads.
4/ Foreign material was separated before portions were split for standard samples. No data provided for "split" samples as in tables 12, 13, and 14.

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